

Nano-biosensors for medical research and services

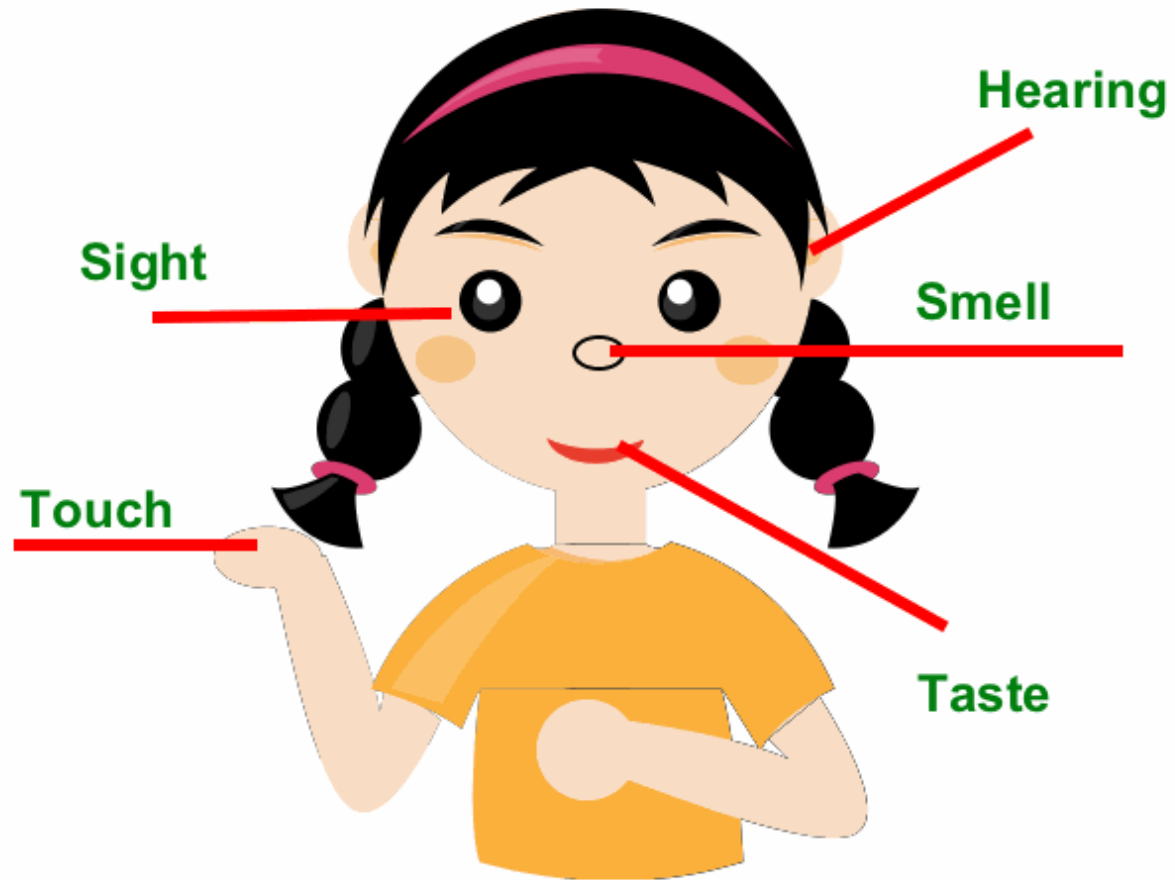
Chatdanai Lumdee (Tua)



Nanosensors

Nanosensors

My Five Senses



By: Roberta L.



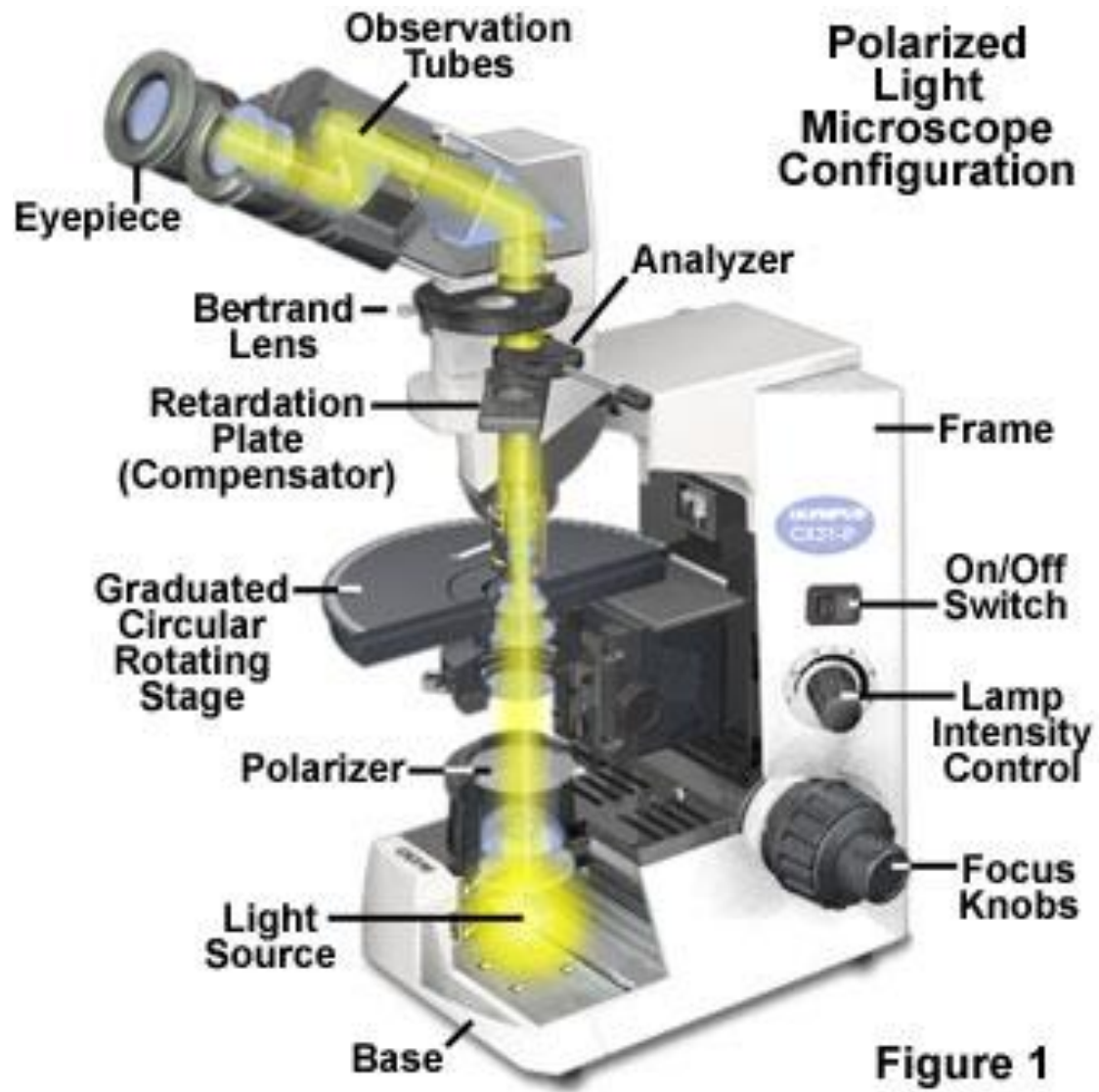
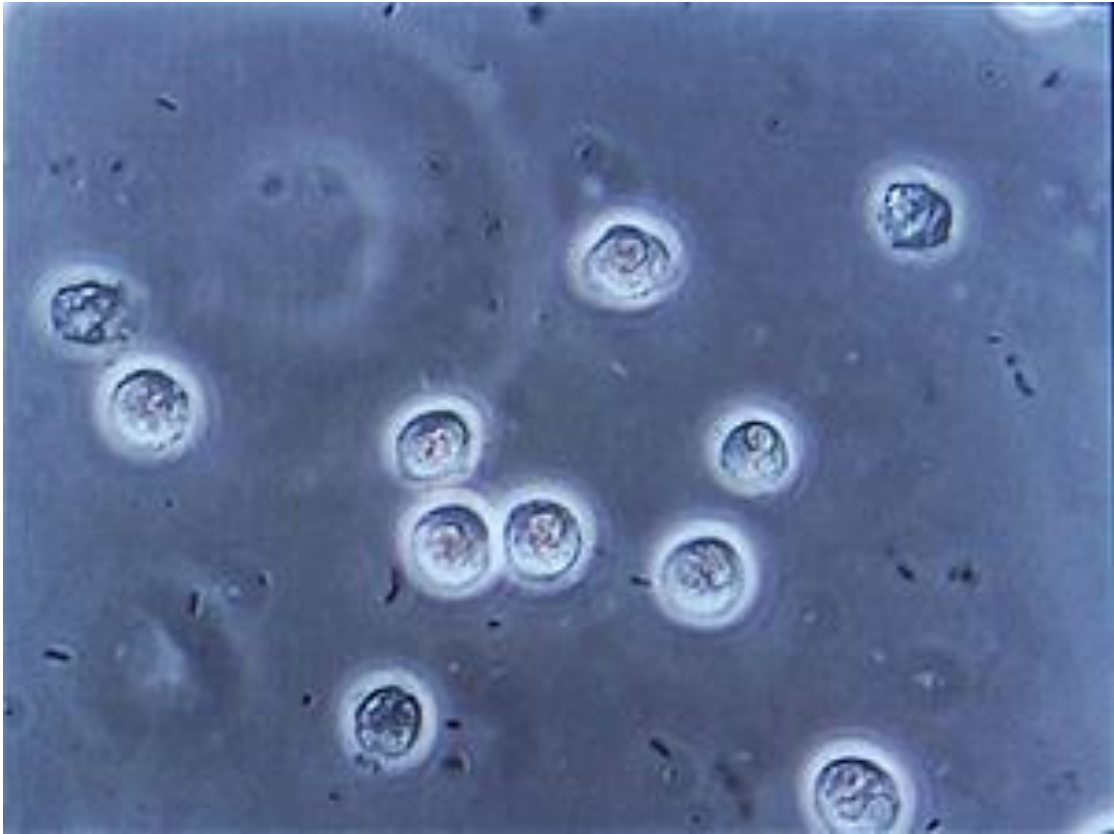


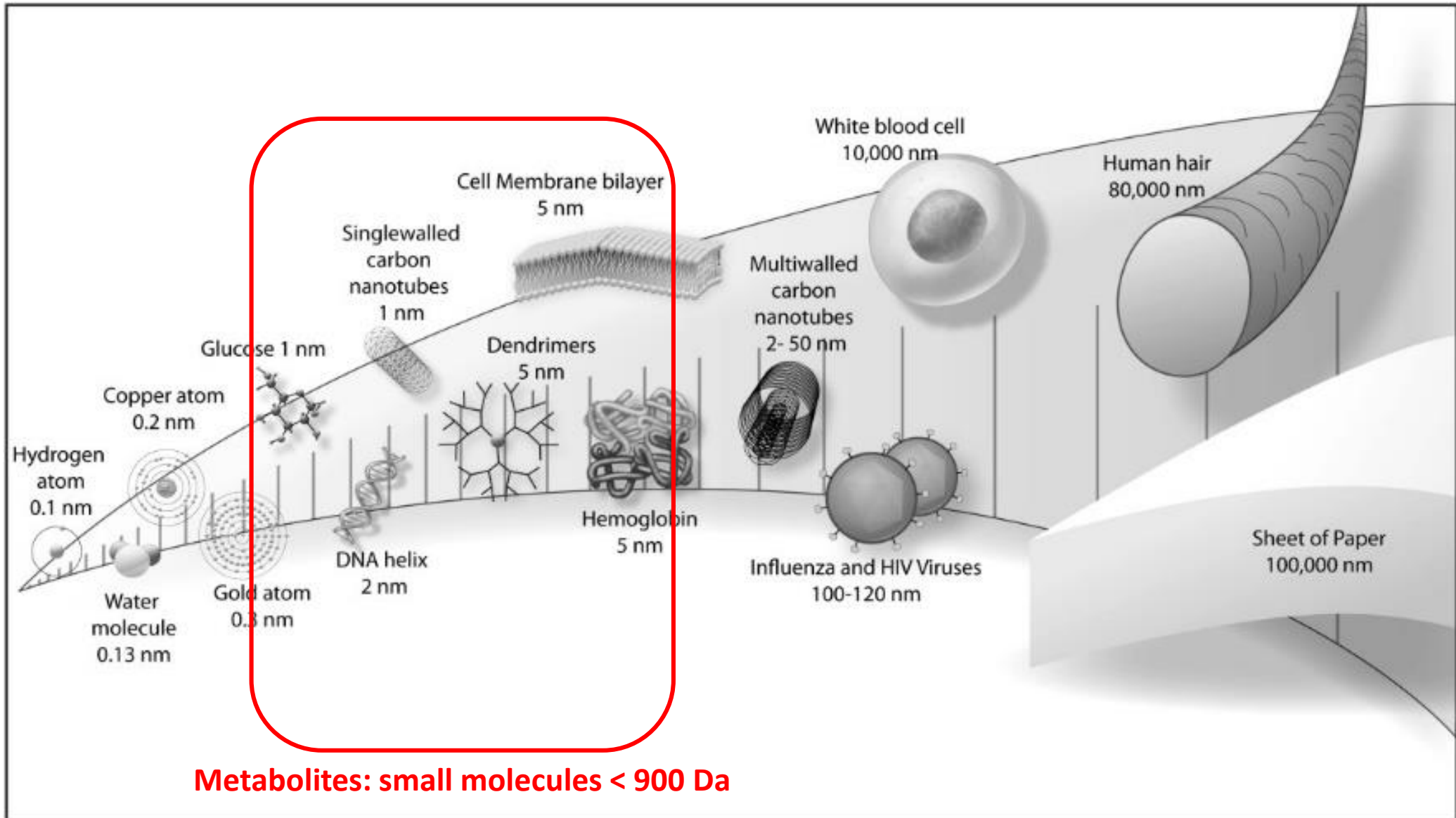
Figure 1

Most bacterial cells range in size from **0.2 to 10 microns**



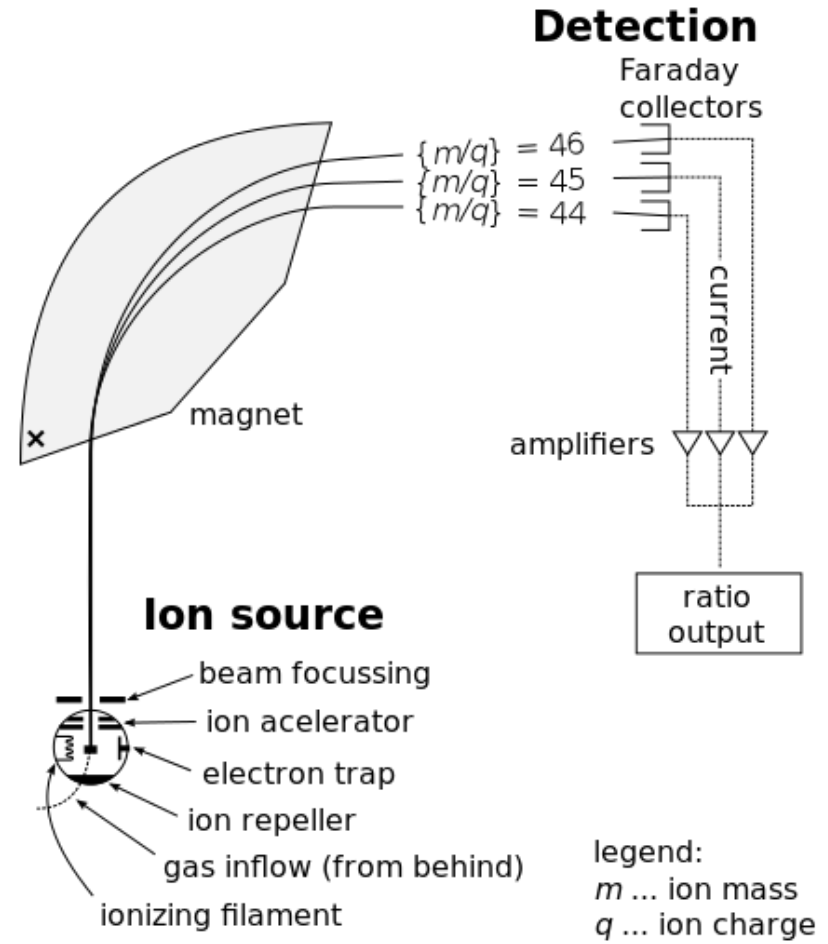
Multiple rod-shaped bacteria shown between the larger white blood cells at urinary microscopy

White blood cells ~10-15 um



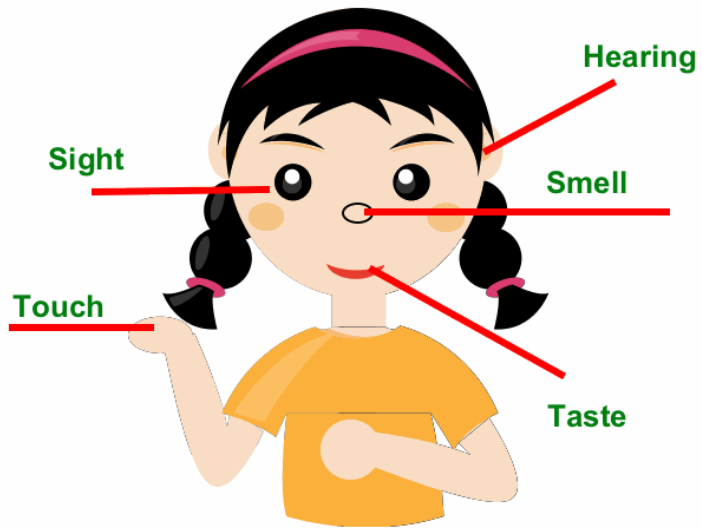
Metabolites: small molecules < 900 Da





Nanosensors

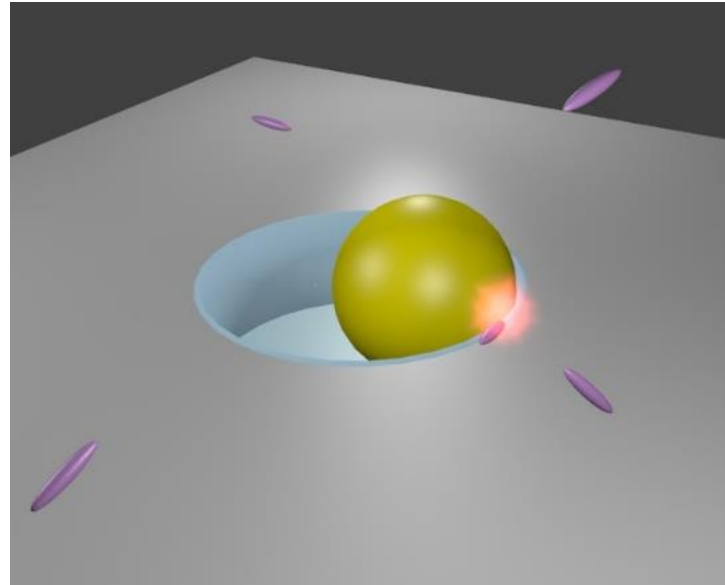
My Five Senses



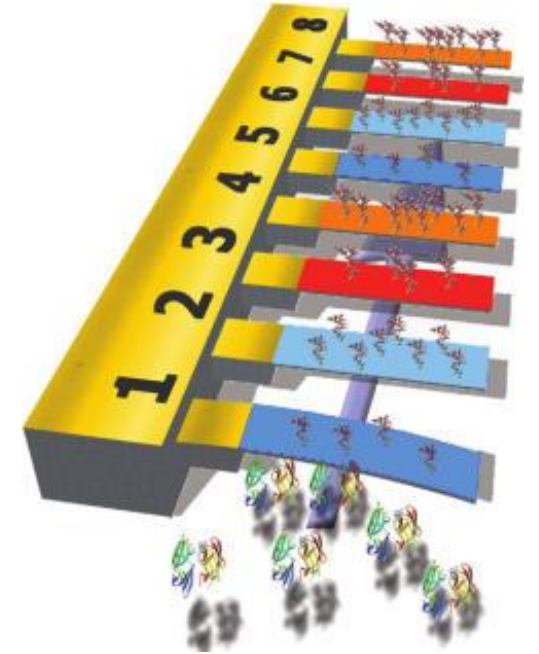
By: Roberta L.



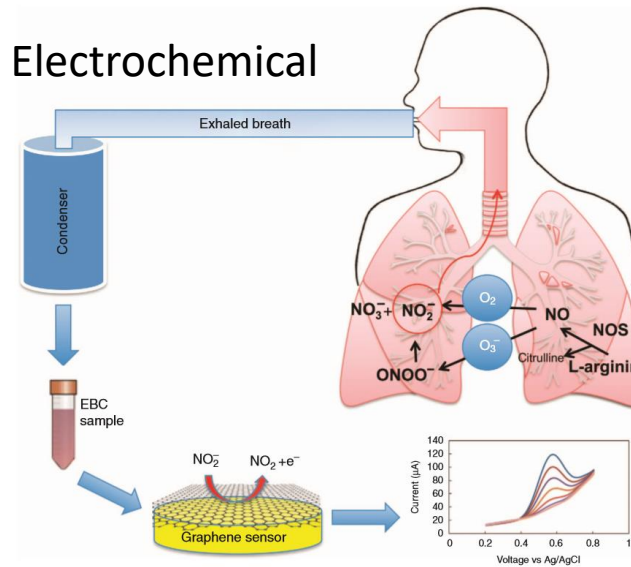
Optical



Mechanical



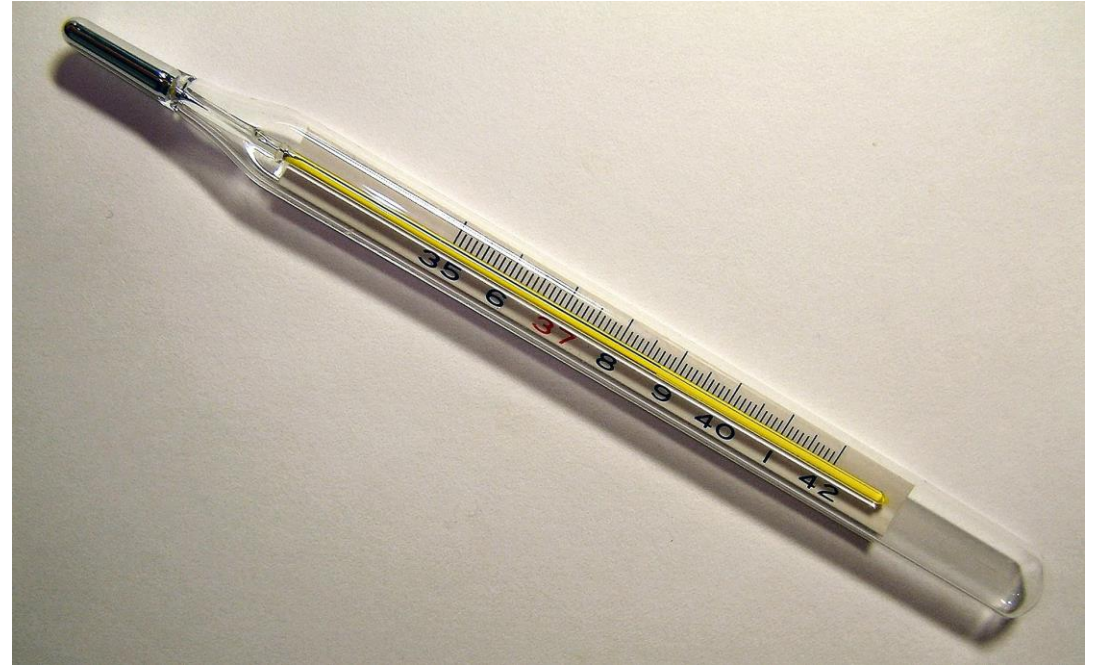
Electrochemical



Mechanical sensors

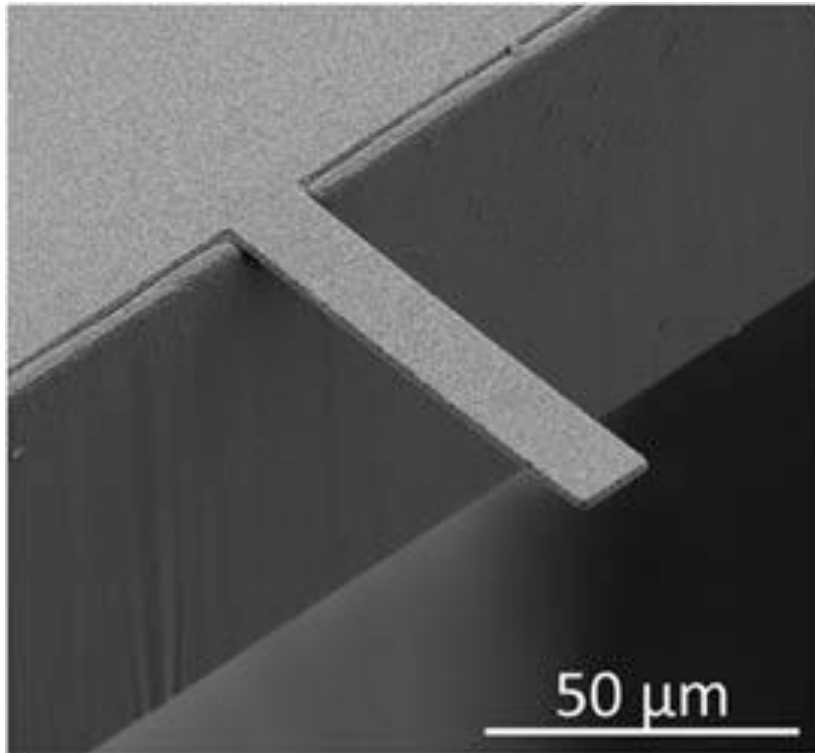


Body weight scale



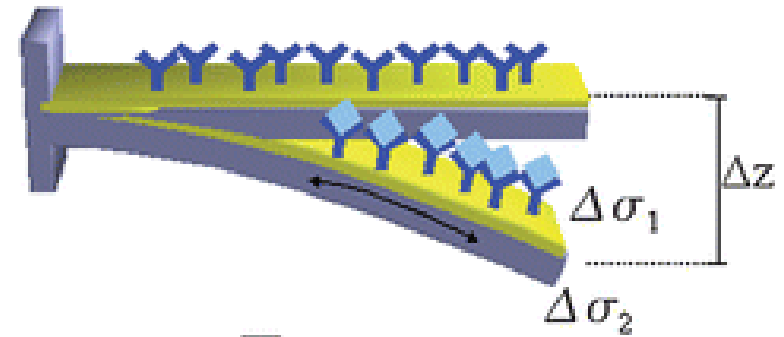
A medical/clinical thermometer

Mechanical sensors

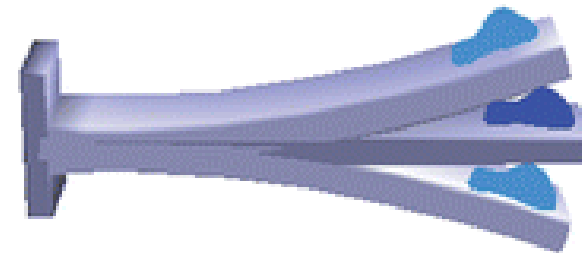


<http://www.microchem.com/Appl-MEMs-Cantilevers.htm>

a)
$$(\Delta\sigma_1 - \Delta\sigma_2) = \frac{Et^2}{3(1-\nu)L^2} \Delta z$$

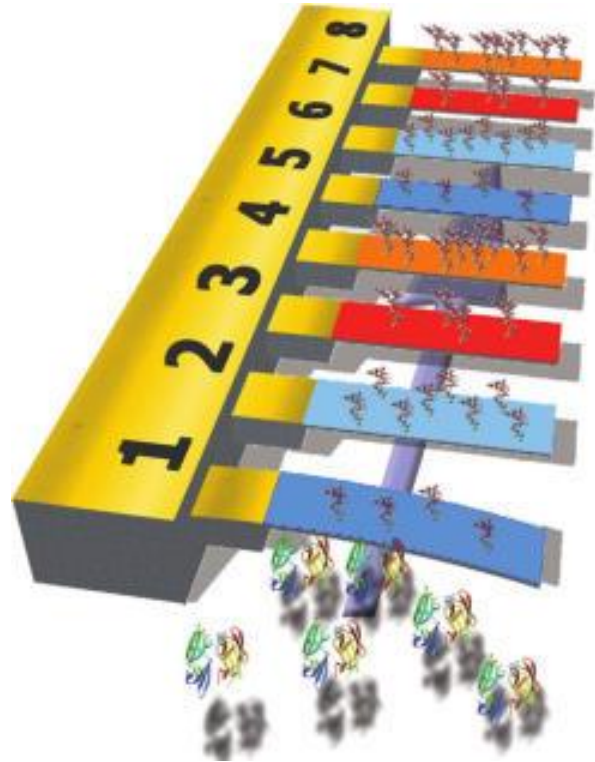


b)
$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$



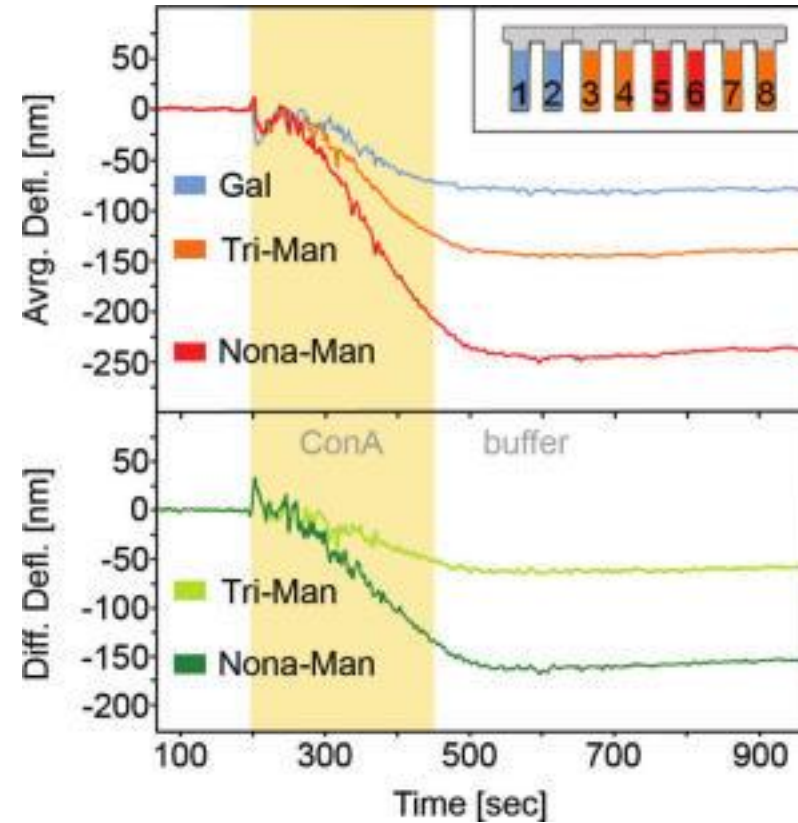
Analyst (2010), 135, 827

Mechanical sensors



ACS Nano (2011), 5, 3670

Cantilever Array Sensors Detect Specific Carbohydrate-Protein Interactions with Picomolar Sensitivity



Cyanovirin-N (CV-N) is a protein produced by the cyanobacterium *Nostoc ellipsosporum* that displays virucidal activity against several viruses, including human immunodeficiency virus (HIV)

Electrochemical sensors

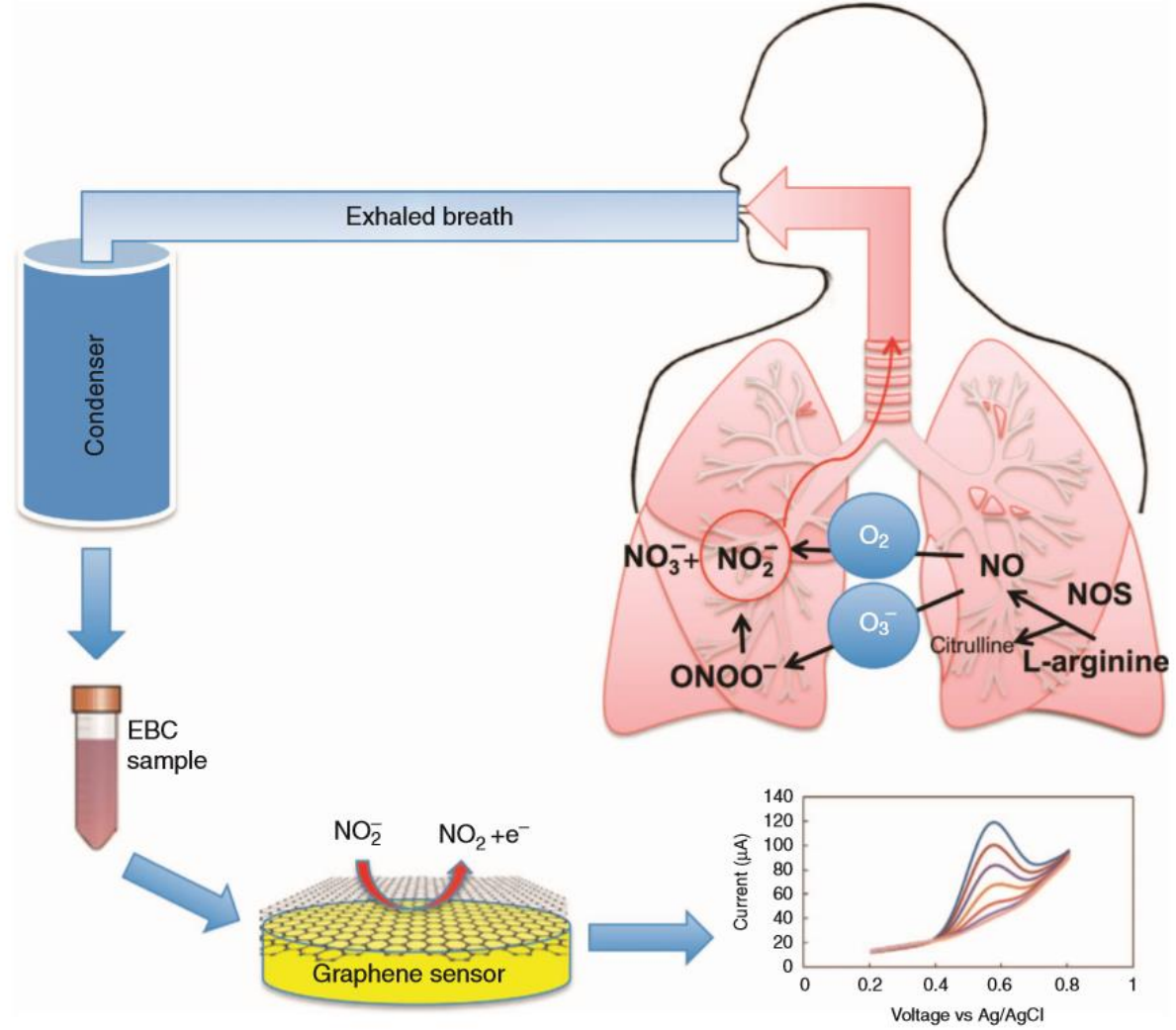


NIOX VERO Medical device for measurement of exhaled nitric oxide

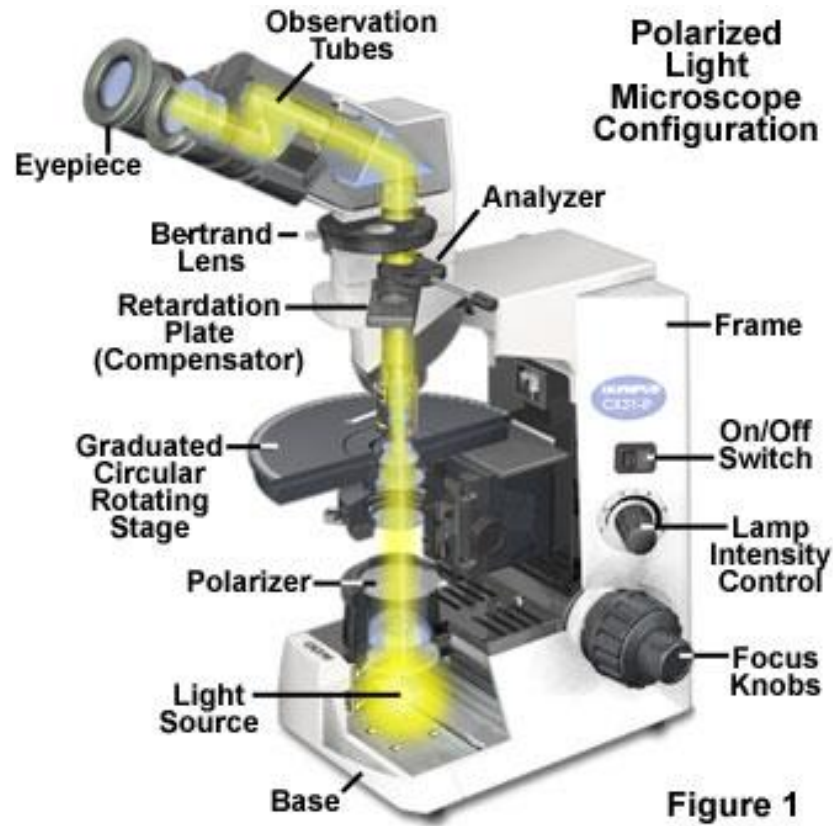


Blood glucose monitoring device

Electrochemical sensors



Optical sensors



Optical microscope



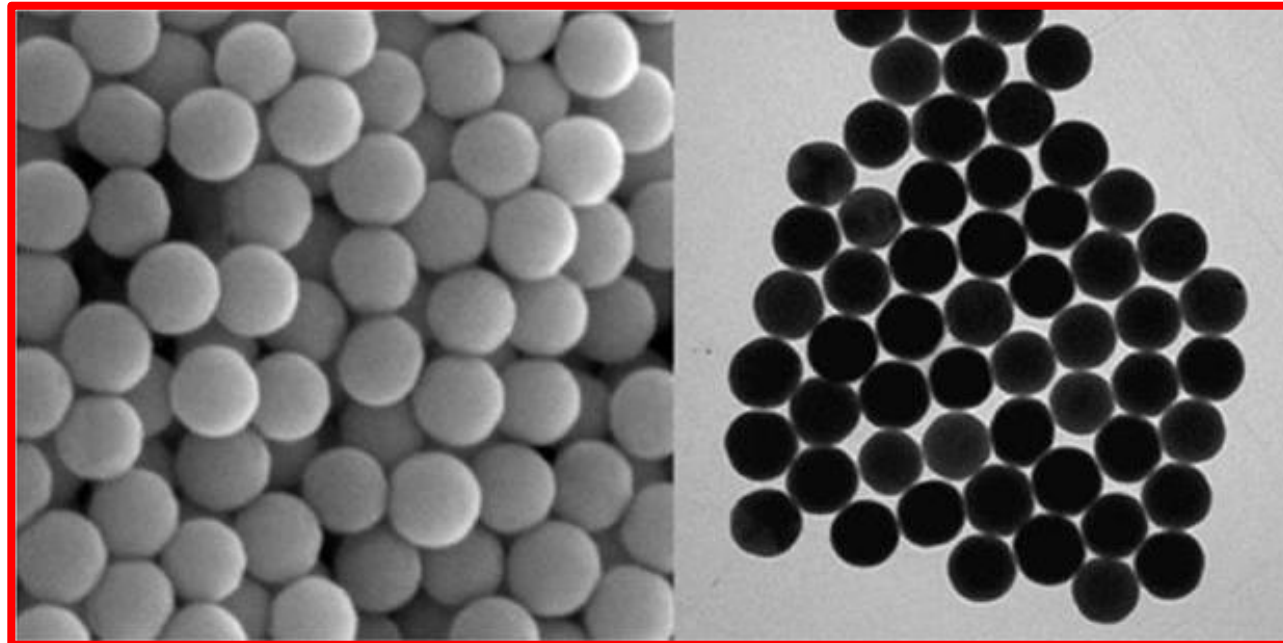
X-ray scan

Examples → absorption, scattering, fluorescence

Optical nanosensors

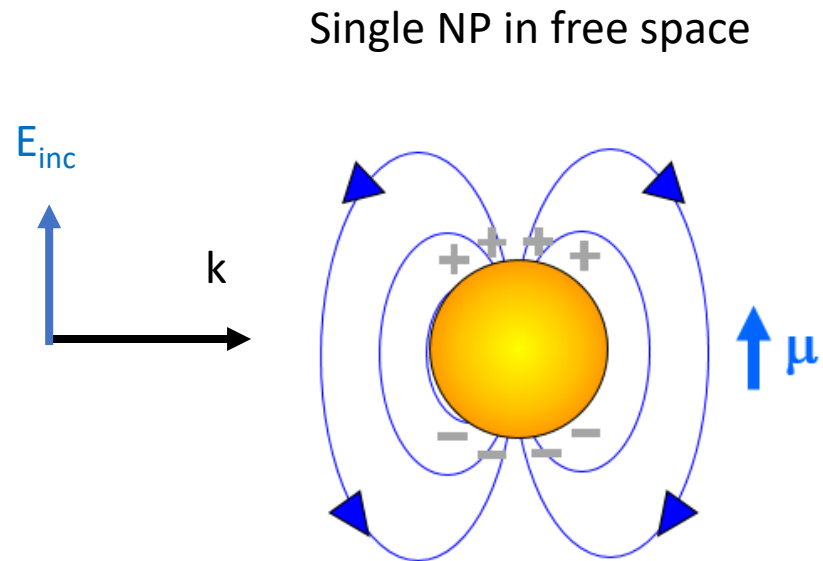
How nanostructures can help?

Simplest form → nanosphere

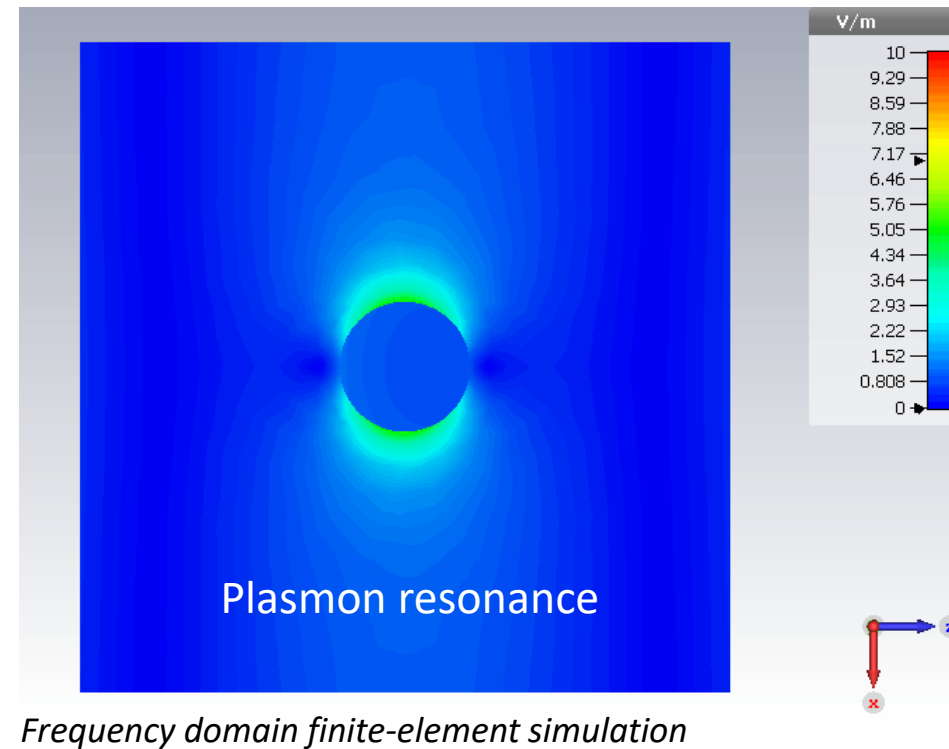


ACS Nano 7, 11064 (2013)

Optical nanosensors



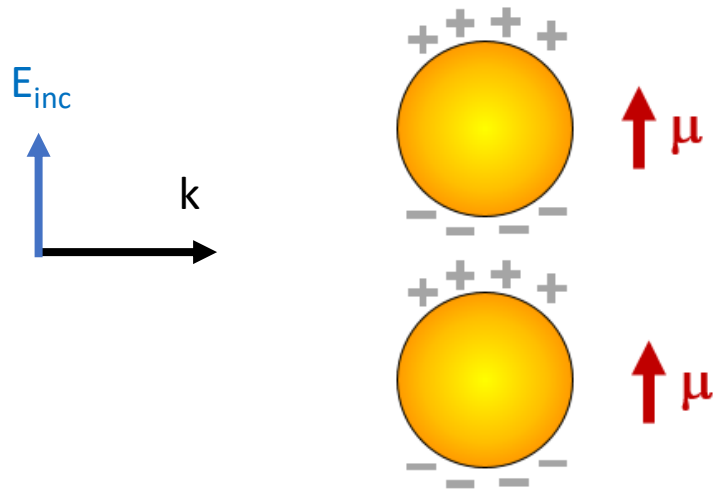
50 nm diameter Au NP nm diameter in water



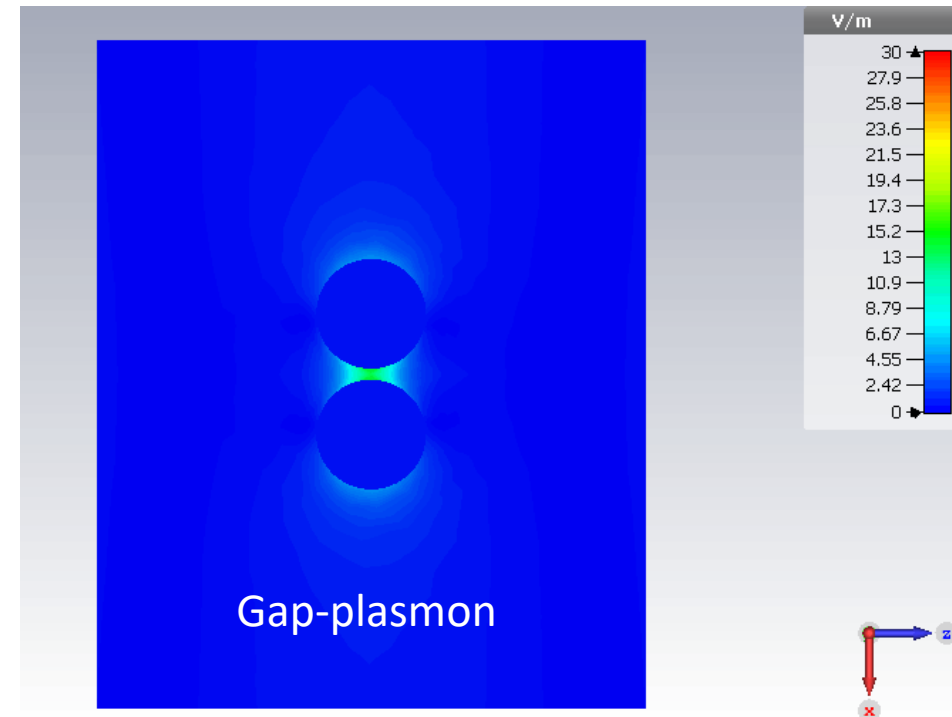
Active optical volume *almost* in the same order as a metabolite

Optical nanosensors

NP dimer in free space



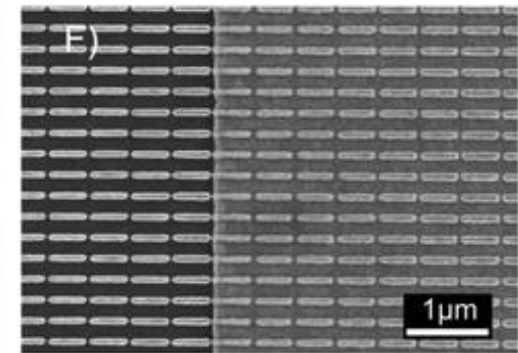
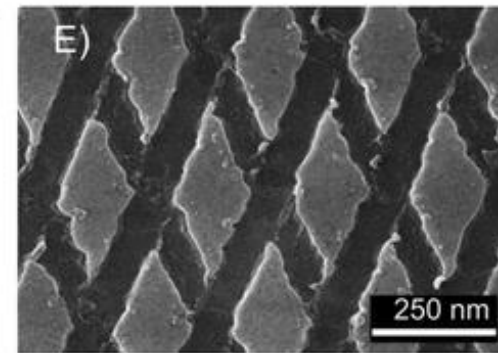
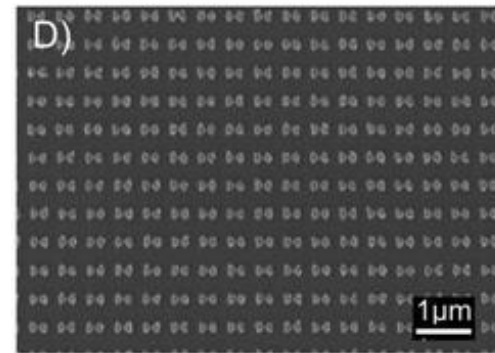
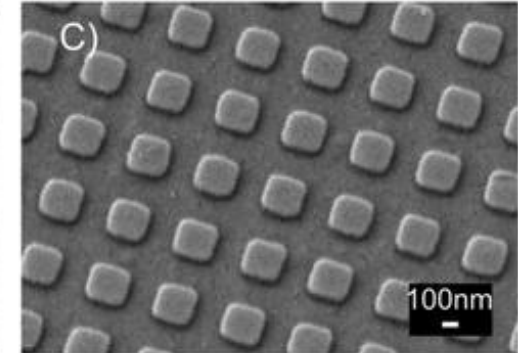
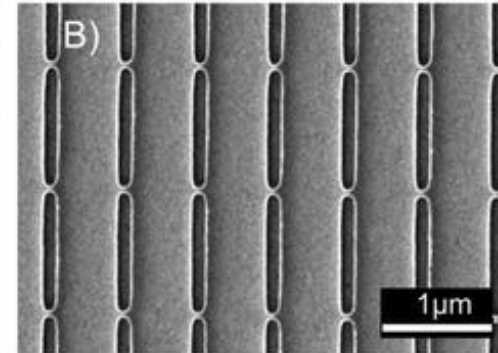
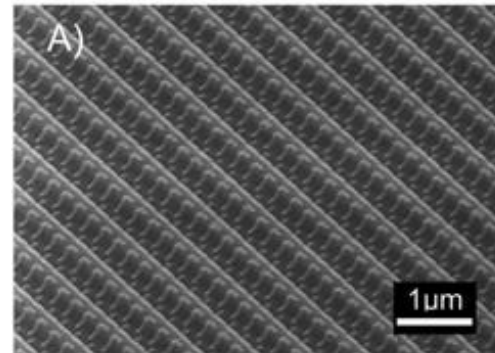
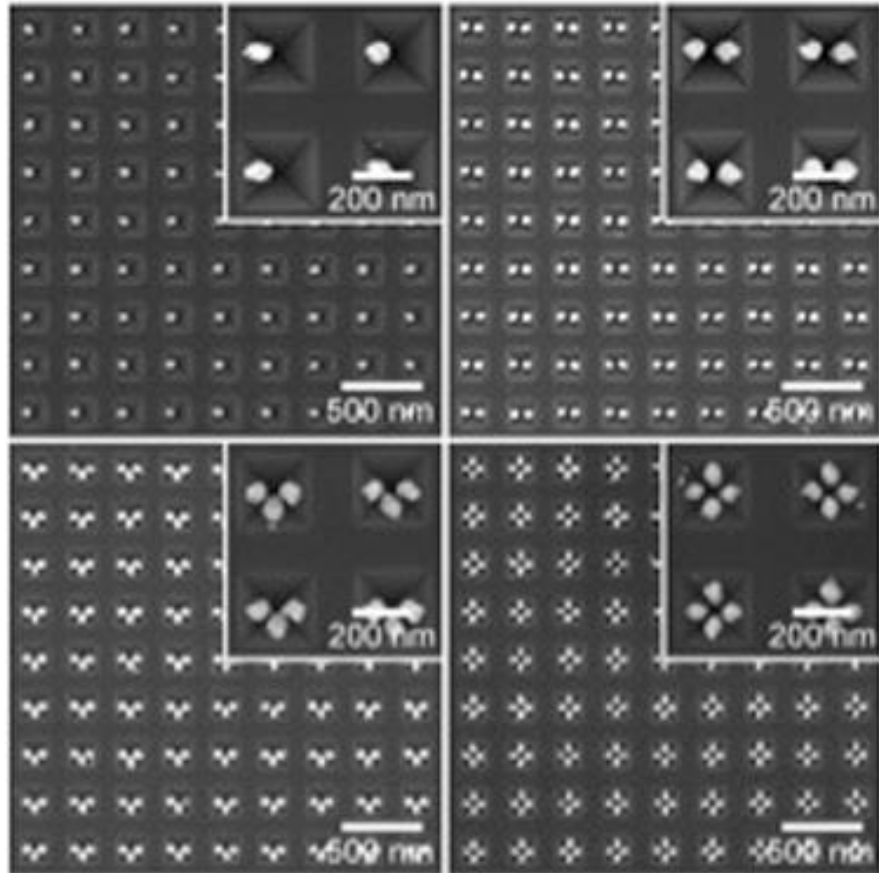
50 nm diameter Au NP dimer (5 nm gap) in water



Frequency domain finite-element simulation

Active optical volume in the same order as a metabolite

Optical nanosensors

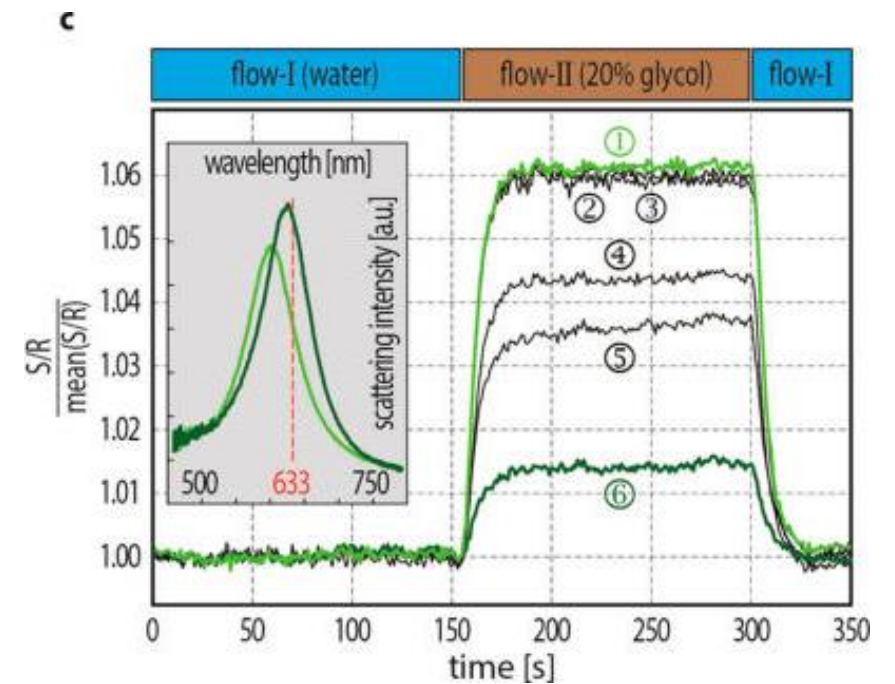
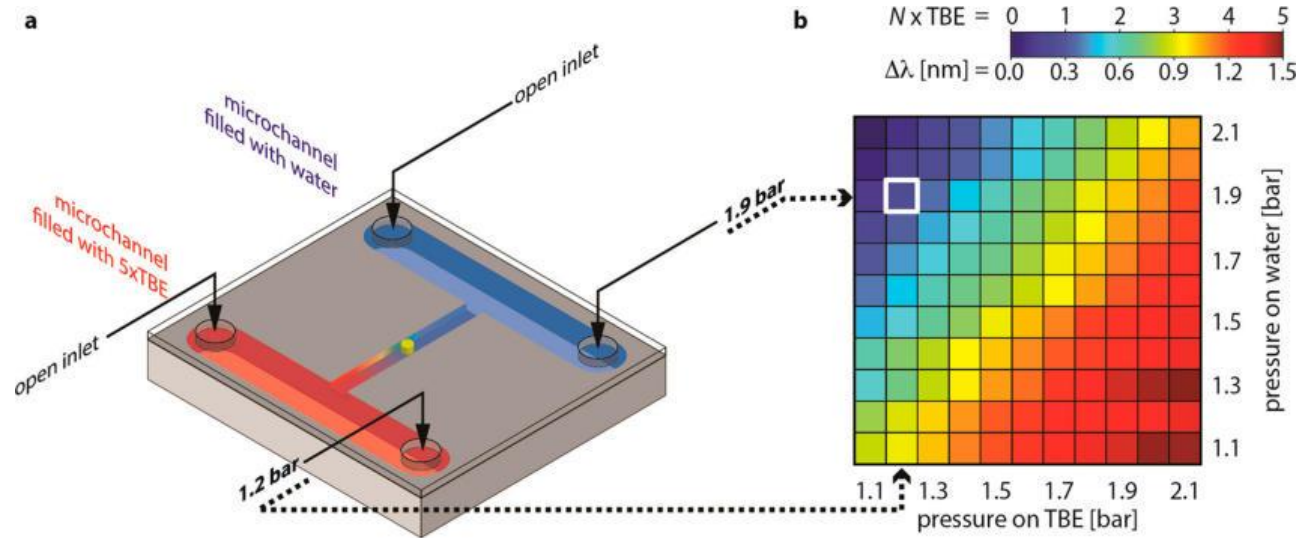
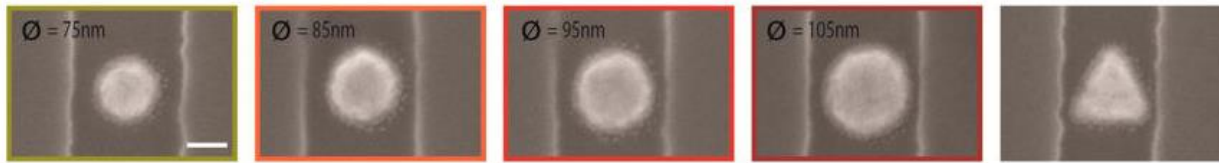


(Review) Analyst (2016), 141, 756

ACS Nano (2014), 8, 7639

Optical nanosensors

Single Particle Nanoplasmonic Sensing in Individual Nanofluidic Channels

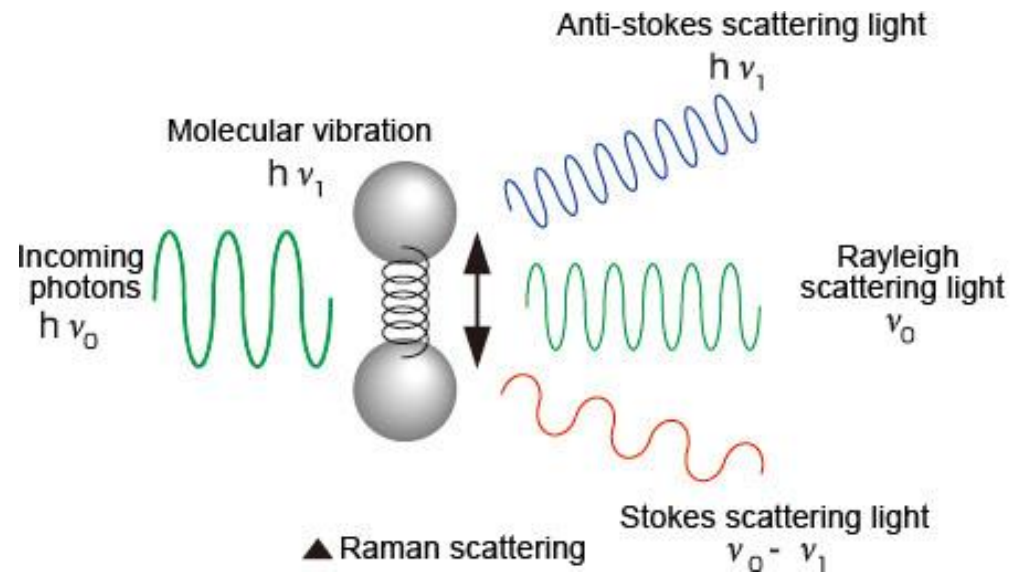


Nano Lett. (2016), 16, 7857

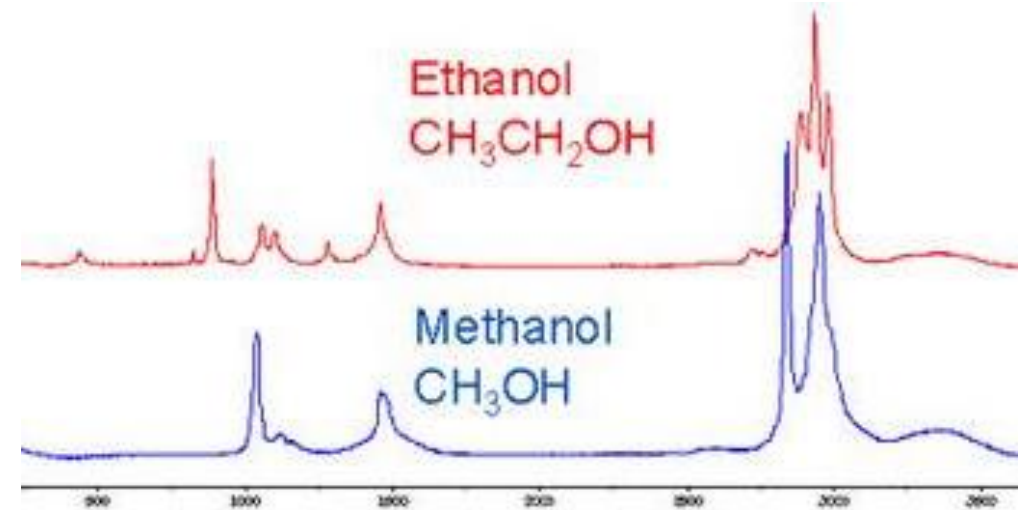
Is labeling necessary?



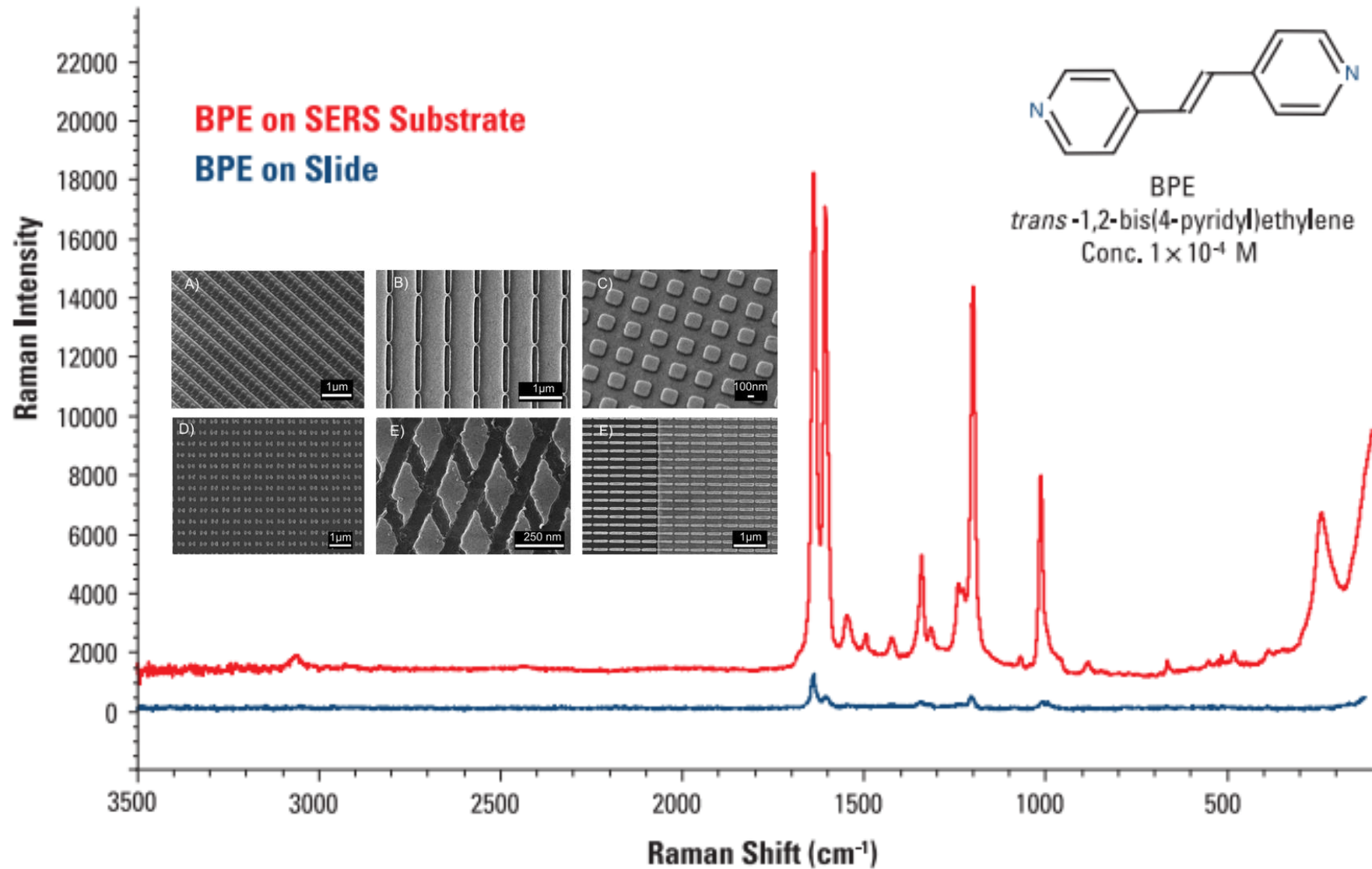
Toward non-labeled detection: Raman scattering



<http://www.hamamatsu.com/eu/en/technology/lifephotonics/environment/SuperiorDetectionOfDiverseChemicals/index.html>

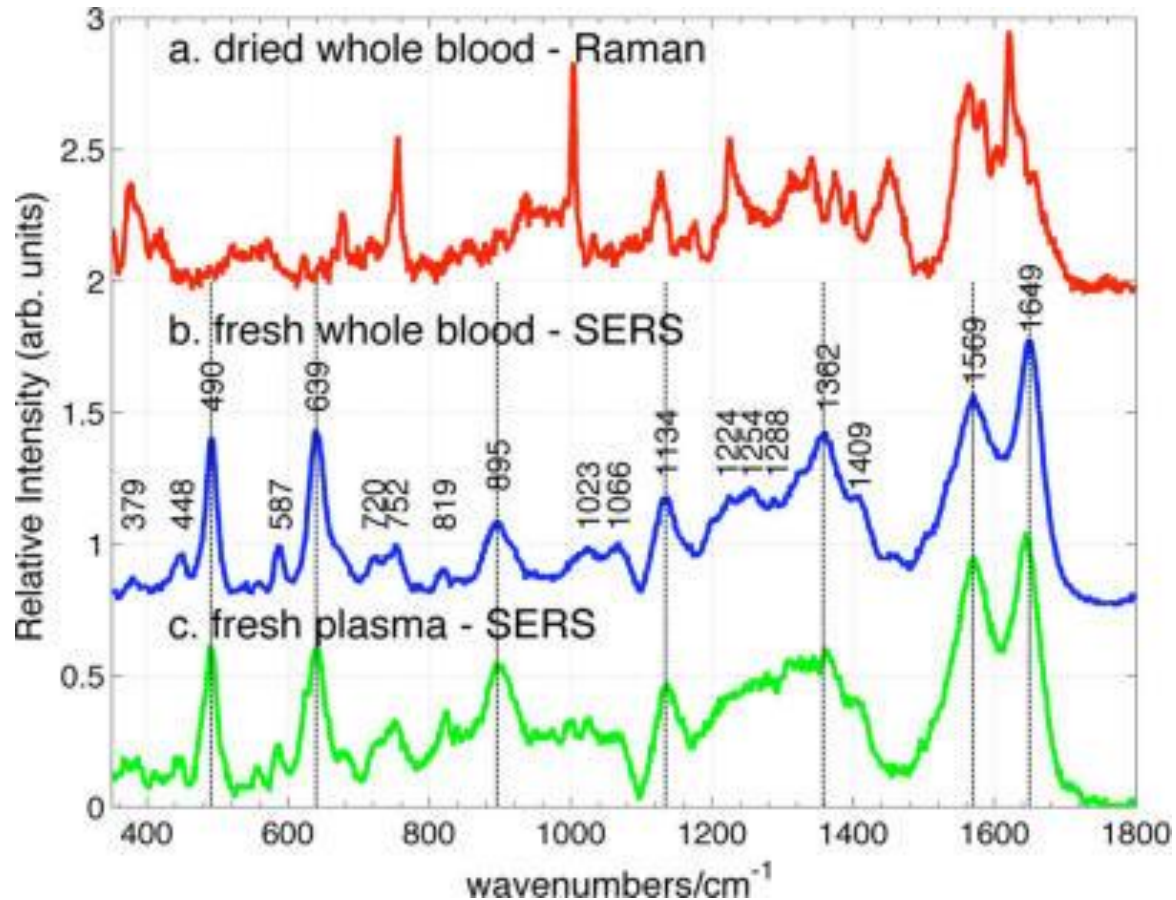


<http://www.horiba.com/us/en/scientific/products/raman-spectroscopy/raman-academy/raman-faqs/what-information-does-raman-spectroscopy-give/>



Comparison of Raman spectrum of a BPE solution on a plain surface (bottom, blue line) and on a commercial SERS substrate (top, red line) measured at the same conditions

Biofluids/bodily fluids contain several metabolites



<https://da-dk.mostphotos.com/365650/mess-of-cables>

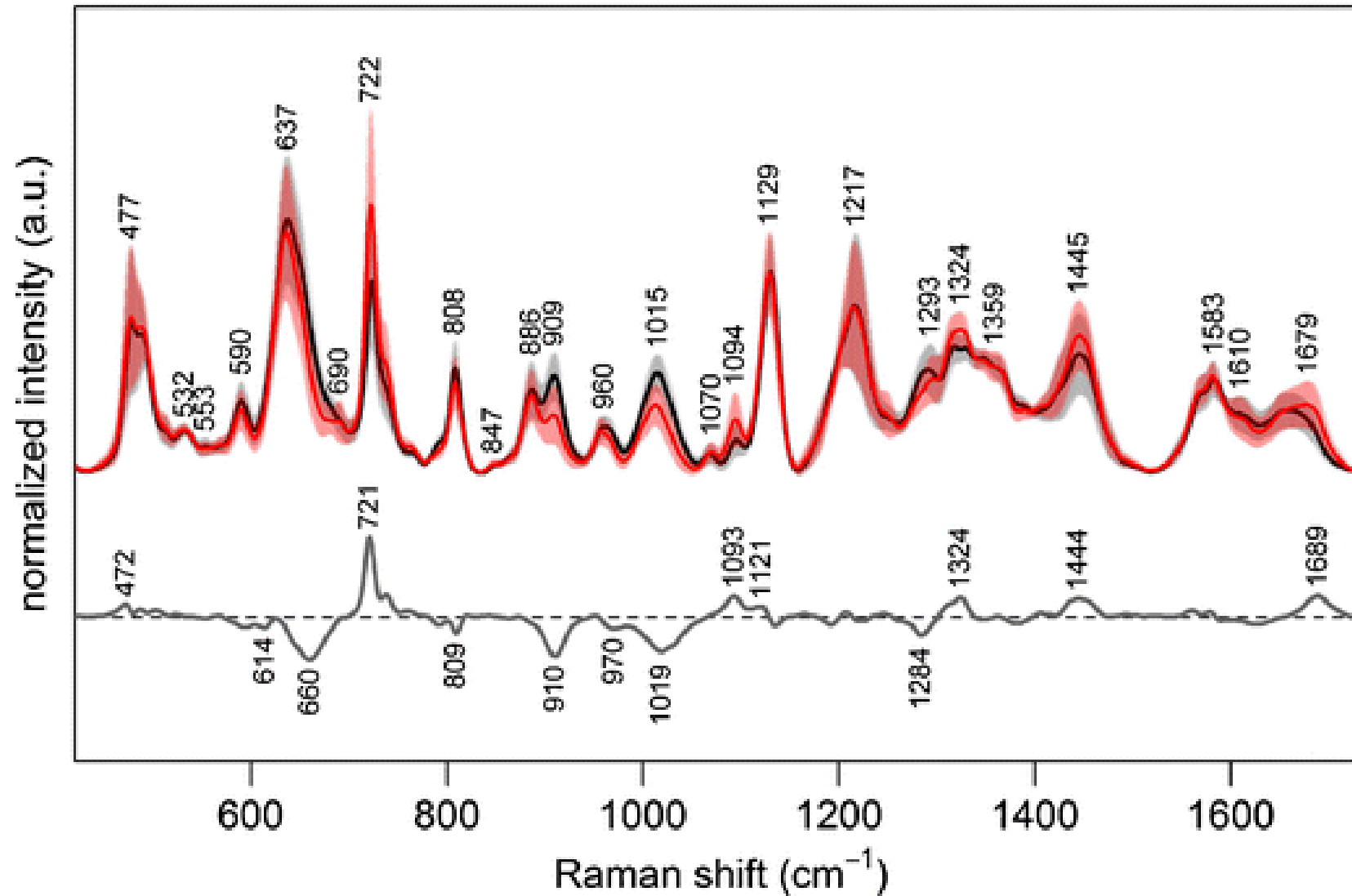
The 785 nm excited (b) SERS spectrum of fresh whole blood compared to (a) normal Raman spectrum of dried whole blood and (c) SERS spectrum of fresh plasma. The peak positions of the bands in the SERS spectrum of fresh whole blood are given in (b).

J. Phys. Chem. B (2012), 116, 9376

Machine learning (i.e. statistics)




SERS + Machine learning → breast cancer detection




SERS + Machine learning is catching fire




 Surface-enhanced Raman spectroscopy of urine for prostate cancer detection: a preliminary study


Anal Bioanal Chem (2015), 407, 3271

 Optical diagnosis of malaria infection in human plasma using Raman spectroscopy


Journal of Biomedical Optics (2015), 20, 017002

 Conductive silver paste smeared glass substrates for label-free Raman spectroscopic detection of HIV-1 and HIV-1 p24 antigen in blood plasma

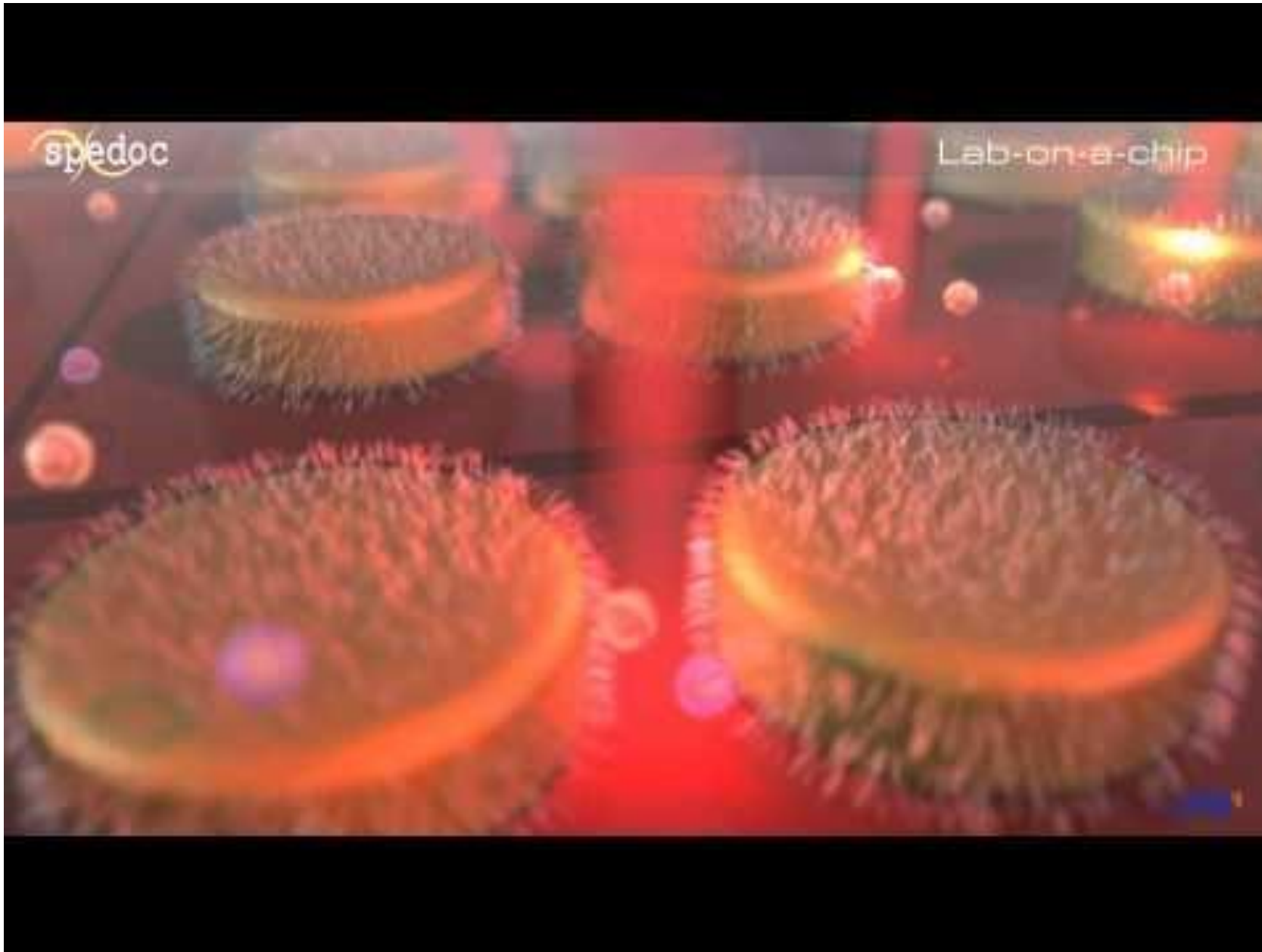
Anal Bioanal Chem (2017) 409:3253–3259

 Optical diagnosis of dengue virus infection in human blood serum using Raman spectroscopy

Laser Phys. Lett. (2013), 10, 035602

 Label-free blood serum detection by using surface-enhanced Raman spectroscopy and support vector machine for the preoperative diagnosis of parotid gland tumors

BMC Cancer (2015), 15, 650



A new method for early cancer detection -- <https://www.youtube.com/watch?v=5GFoH5cwFGQ>





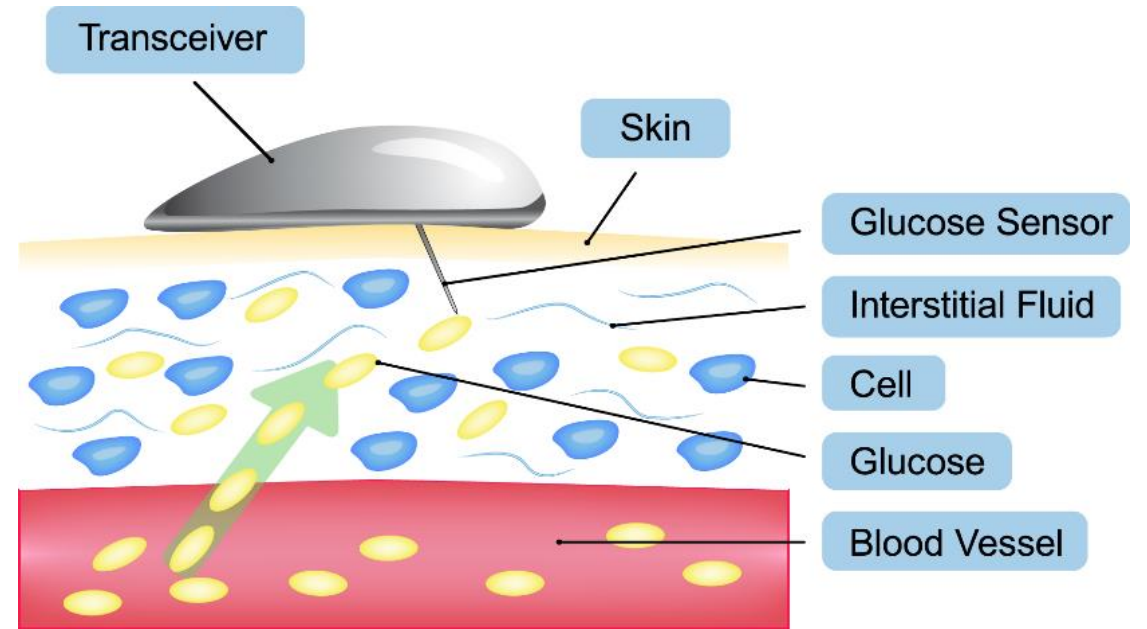
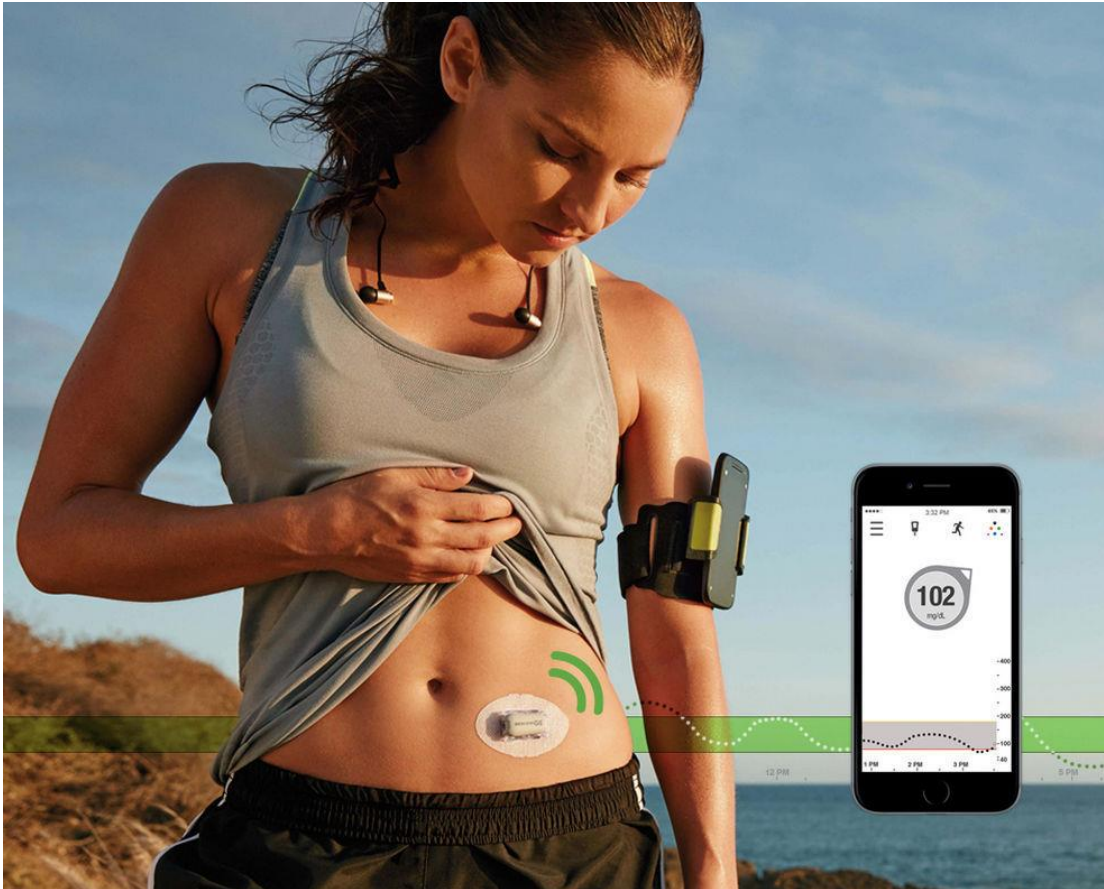
By MARY BROPHY MARCUS | CBS NEWS | February 9, 2016, 11:42 AM

Fitbit fitness tracker detects woman's pregnancy



A Fitbit tracks heart rate, steps, sleep, and calories, and apparently gives clues a woman may be pregnant, a man learned after thinking the fitness tracker was just faulty. His wife was wearing a Fitbit Surge. / **FITBIT**

Continuous Glucose Monitoring



How Machine Learning Is Helping Us Predict Heart Disease and Diabetes

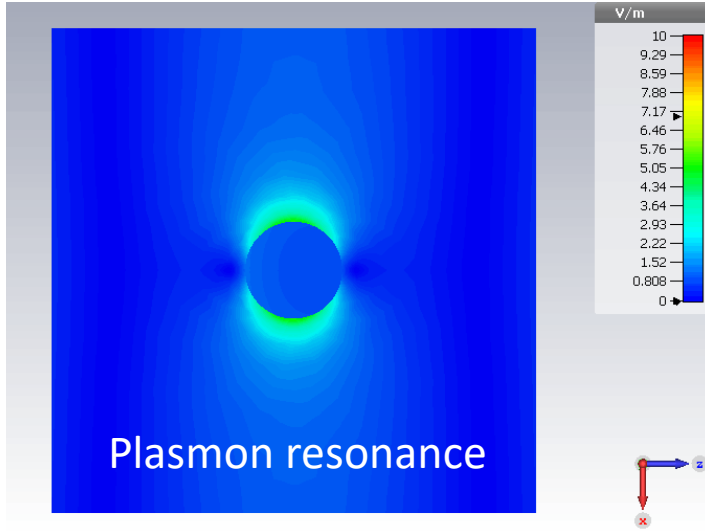
by Yannis Paschalidis

MAY 30, 2017

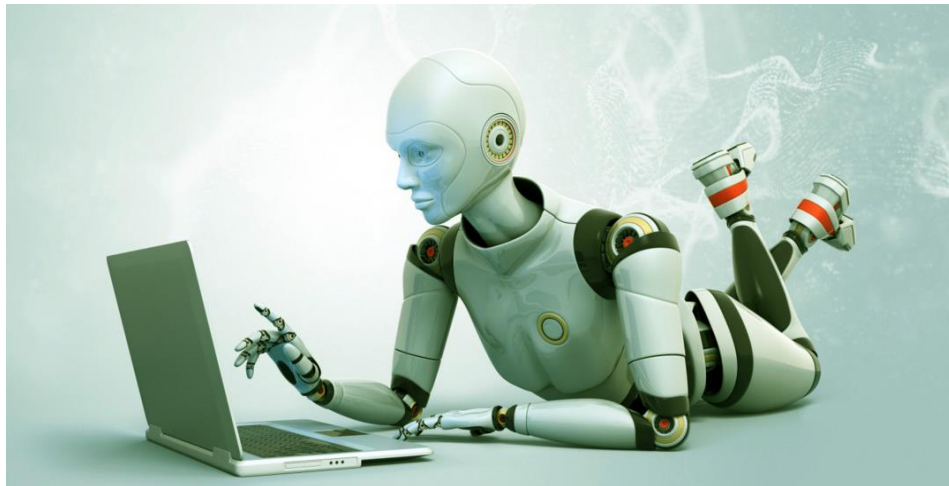


Summary

Nanoscale phenomena



Big data and machine learning



Raman and surface enhanced Raman spectroscopy

